ADVANCED MECHATRONICS

PROJECT REPORT

Ultra Vision Kit

Team:

Gaurav Shetty

Matteo Tortorella

Vignesh Pai

Professor:

Prof. Vikram Kapila

Date: 05/11/2017

1. ABSTRACT

The objective of this project is to design and prototype wearable assistive technology for a blind person. In order to effectively guide a visually impaired patient through his environment, our team decided to develop a mechatronics kit consisting of an ultrasonic head/hand wear, a GSM Arduino module, a voice recognition module and a pair of computer vision glasses. The ultrasonic head/hand device is intended to be worn to detect the presence of objects in the peripheral of a person and provides a mild vibratory feedback to indicate the presence of the object in his/her vicinity. The computer vision glasses are meant to become the “artificial eyes” of a patient, since with the aid of AI and computer vision techniques one can effectively detect and get an audio description of various objects of interest. The GSM module is used to contact family, friends or authorities in case of an emergency, and the voice recognition module has been included to aid a visually impaired person when using the kit in practice. In this project, we have conducted initial preliminary design and prototype of a wearable sensing and computing interface consisting of an Arduino microcontroller, a Raspberry Pi microcontroller, several sensors, feedback actuators, a GSM Arduino module and a voice recognition Arduino module. This system is envisioned to help a blind person navigate with confidence, to be aware of overhanging obstacles and intrusions which a traditional white cane cannot detect. Most importantly, the system includes a wearable glasses platform that can be modified and customized to detect and recognize various objects depending on the interest and needs of particular blind individuals.

2. INTRODUCTION:

Statistics regarding the population of visually impaired people are staggering and highlight the importance of this project from both the engineering and commercial perspectives: in the US only, there are 28,950,000 visually impaired people, of which 24.8 % have access to a smartphone, live in urban areas and can afford wearables that cost less than a smartphone. Given this information there are a total of 7,200,000 addressable patients in the US. Focusing on a slightly more global perspective, looking at developed territories in Europe and Japan for example, we could address 6,800,000 and 2,400,000 users respectively. The reason why most of the blind people worldwide cannot still be addressed is that they live in areas that are too underdeveloped to support the use of effective assistive technology. But it is easy to understand that the number of addressable patients will grow proportionally to population growth and technological trends.

Blindness is a challenging problem to solve, but a complete mechatronics kit can greatly aid an impaired user. Numerous animal species use ultrasounds in order to navigate, so an ultrasonic wearable solution is definitely effective in giving feedback about the environment. The ultrasonic wearable is simpler than what it sounds: the ultrasonic sensors capture distance measurements and the cutaneous disks activate accordingly, with a vibration intensity directly proportional to the distance. Vibration intensity indicates object distance, and object direction is automatically understood based on where the vibrating disk is placed: if an element on the user's elbow is vibrating at maximum intensity, for example, means that there is an object closer than 10 cm in the elbow's direction. Once a user is conscious of exactly in what direction and at what distance surrounding objects are, he would like to know particularly what kind of objects they are, and, in order to detect and recognize objects, computer vision techniques are required. For this reason, CV glasses are introduced in order to take pictures of objects and process images. The glasses have an ip camera to capture images and a pair of ear speakers so the user can receive the desired description of particular features in images. A GSM module has been added for emergency contacts, since it is safe to assume that extra independence, given by the ultrasonic and CV solution, will increase the probability of a user putting himself at risk. A voice recognition module has been added to easily control the functioning of the ultrasonic device and the GSM with the use of vocal commands, especially in emergency situations.

3. BACKGROUND:

In this section contains descriptions of all the required components.

3.1 Arduino Microcontroller

Arduino is an open source microcontroller, excellent to interface digital devices that can sense and control objects in the physical world. For this reason the Arduino is the controller responsible for the functioning of the ultrasonic sensors, vibrating disks, GSM module and the voice recognition module, which will be described in the next subsections.

3.2 Raspberry Pi 3 Model b Microcontroller

The Raspberry Pi is a single board computer, and for this reason it can be used effectively for heavy data extraction and management tasks, online/offline data processing etc. So, the Pi is the processor dedicated to computer vision, since AI and machine learning require huge amounts of data to operate.

3.3 Ultrasonic Sensor

This is the HC-SR04 ultrasonic ranging sensor. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit. There are four pins on the HC-SR04: VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground).

Also, the trigger and receive pins can be tied together and activated sequentially, in order to avoid using an extra processor control pin. They're never active at the same time. The receiver is locked out for a very brief period after the pulse is sent. This helps optimize the use of Arduino.

3.4 Vibrating Disk

The vibrating mini motor disk is a shaftless vibratory motor and provides haptic feedback and is perfect for non-audible indicators. These vibe motors are tiny discs, completely sealed up so they're easy to use and embed. With a 2-3.6V operating range, these units vibrate at high frequency at 3V. Once anchored to a PCB or within a pocket, the unit vibrates softly but noticeably. This high quality unit comes with a 3M adhesive backing and reinforced connection wires.

The frequency of the vibrations alters according to the range at which the object is detected. Each ultrasonic sensor is interfaced with an individual vibrating disk, so that the wearer realizes the direction of the object and the distance at which it is in every direction.

3.5 Arduino GSM/GPRS Module

This is a very low cost and simple Arduino GSM and GPRS shield. Specifically, the module SIMCom SIM900 was used in this experiment. To provide an additional safety feature, the blind person can send an emergency alert text message or call to the concerned authority in case of immediate assistance. This proved invaluable in a situation such as a heart attack or a fall. We have chosen an Arduino GSM/GPRS shield to realize this task. When we add to the shield a SIM card which provides GSM coverage (a T-Mobile card does), it can send text messages and make calls.

3.6 1Sheeld

Voice recognition shield used to control the ultrasonic solution and GSM communication with user voice commands.

3.7 HD 1080P 8MP Wifi Mini DIY Module Spy Camera

IP camera attached to the glasses in order to take pictures or record video, very small and convenient to use.

4. RESULTS AND DISCUSSION

The prototype is very effective in demonstrating the basic functioning of the whole system. The ultrasonic wearable and the GSM controlled with voice work well and are very practical. The most interesting results come from the computer vision glasses:

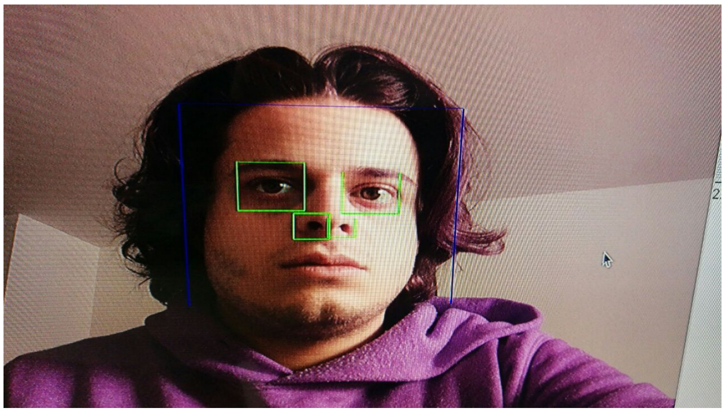

Fig. 1) Facial detection example.

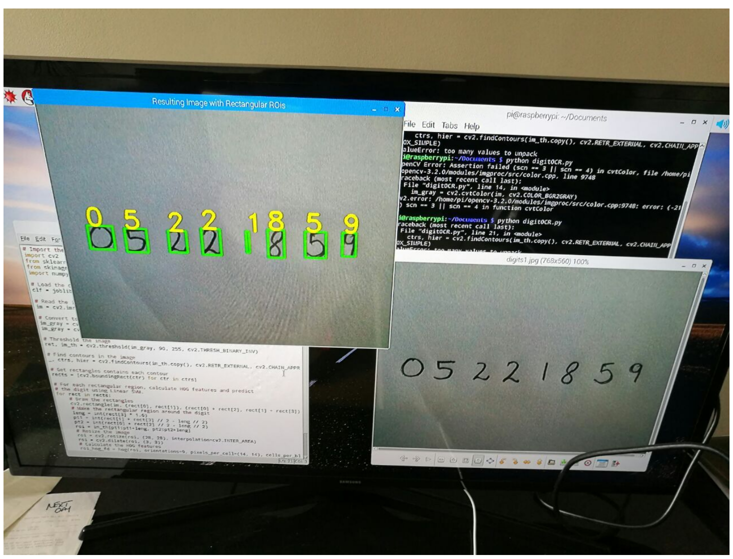

Fig. 2) Simple handwritten digit recognition example.

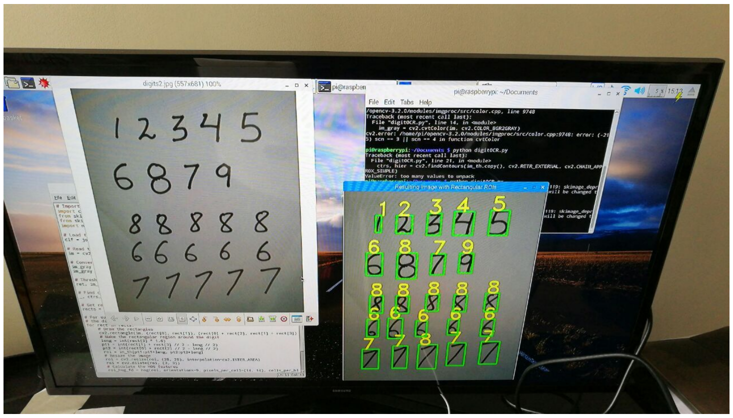

Fig. 3) Harder handwritten digit recognition example.

Computer vision in the Raspberry Pi generally works well when analyzing clean and ideal images. Figure 1 shows a computer vision dedicated to facial detection example, while figures 2 and 3 show examples where computer vision is applied to recognize and read handwritten digits. While the facial detection part works well most of the time, especially with less than ideal images, the digit recognition part fails way more frequently. The reason for this is that facial detection is a relatively simpler task than digit recognition, since a lesser number and simpler image feature patterns need to be analyzed in order to achieve facial detection. For this reason we had to introduce image thresholding in the digit recognition software, in order to clean and perfect non ideal images. Unfortunately, the software still includes thresholding parameters that need to be set manually, so it is still not possible to automatically run digit recognition on the glasses at startup, as it is currently happening with facial detection. It is easy to understand that the immediate improvement to add should be in the digit recognition part, where the software needs to be expanded to include an automatic AI process to clean up all possible digit images before they get processed. For digit recognition to be included, all images need to be perfectly cleaned no matter how different they are from one another (shadows, paper ripples etc.).

The feedback that the prototype received from actual visually impaired people is outstanding, as 9 out of 13 test subjects said they would use the kit every day and 11 out of 13 said they would buy the product if available.

„I feel like I'll find myself using this product a lot at home because it will bring me back to do simple things quicker like when I had sight.” Colin Watts

„Your product would be very useful when navigating around big campus buildings like Bobst and Kimmel, I would not bump into people as often. Also, I think it being able to read labels would be helpful as I don't have to ask for help when shopping for food.” Emely

We need to thank the Helen Keller Center For The Blind and Visions Services For The Blind, as these two New York organizations gave us essential help to test our prototype and collaborate directly on the field.